

The construction of the Pure homopolar generator reveals physical problem of Maxwell's equations.

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ABSTRAKT

In this article, we present a part of the research results during 2012-2015, which shows that there must be another description of Faraday homopolar generator than it is generally acknowledged. For example, like a device that simulates necessary and sufficient condition for formation of the induction. Here is presented the experimental Pure homopolar generator (PHG, defined as a generator that does not need any brushes, electronics or semiconductor to ensure the creation of a direct current) as a proof that the movement of electrically neutral conductor in homogeneous circles of magnetic field does not induce any voltage. It is happening in spite of all physico-technological alterations for the purpose of theoretical functionality. These theoretical requirements were achieved by means of the effective shielding by the high temperature superconductors. The reason for this negative result may be the fact that the PHG complies the necessary condition only, but not sufficient. In contrast, the relativistic explanation of Faraday homopolar generator (hereinafter referred to as FHG) seems to be misleading and unrealistic in the context of the article on described experiment. If we still insisted on the correctness of Maxwell's concept, we would have to admit that the non-homogenous field can be shielded from a perspective of any outer system of reference, but such a system of reference for homogenous circles of magnetic field would not exist.

Part of this article is an analysis which shows that the current electrodynamics achieves good agreement between theory and practice, mainly due to the use of tabular electromagnetic constant. These constant represent redundant linear transformation. We show that knowledge of the average field declivity can simplify attainment of the compliance of theory with practice. We introduce a novel conception that improves the experimental prediction. Theoretical impact of the experiment described in this article is fatal with significant practical potential. Despite partially antagonistic results of the experiment with contemporary theoretical ideas, both concepts can coexist in practice with a wide range of value conformities, and need not be necessary to make correction for practical use of current electrodynamics.

Introduction

2015 was the year of the 150th anniversary of the genesis of classical Maxwell equations. We therefore decided continually step by step to confront academic public with the results of our research and analysis. Nowadays we have come to the strong believe that it is necessary to acquaint wider professional community with negative results of the experiment carried out on superconductor shielded PHG and familiarize with the design of concept that can explain this negative result. Our view and results point out contradiction in the physical essence of so-called Faraday's Law describing emergence of electromotive force (EMF) as consequence of the time change of the magnetic flux. The result also shows that the relativistic explanation of Faraday generator can only be modern, but not physically relevant. We show that Faraday's paradox [1] has a dual explanation: Traditional, using the continuity equation, which can be experimentally proven for the flow magnetic field, and unconventional explanation, which shows that the validity of the continuity equation [2] is a weak condition for the formation of the magnetic induction, because it does not explain the non-functionality of shielded

PHG. In this work, we do not come out from hypothetical considerations. We'll exclusively follow the result of the experiment and, on the example of induction, analytically suggest second theory based on more complex interaction between a wire and a field.

Results

Motivation and performed experiments

In 2012, we made an attempt to revive industrial applications based on FHG. The drawback of FHG is the necessity of using brushes. Therefore, an experimental homopolar generator was designed to eliminate this drawback.

Our proposal exactly corresponds to the contemporary theoretical ideas of FHG function. Mathematically it is described by the well-known equation formulated by James Clerk Maxwell around 1865 [3, 4]

$$\mathcal{E}_m = -\frac{d\Phi}{dt} = \oint_l \vec{E}_m \cdot d\vec{l} = \int_S \text{rot} \vec{E}_m \cdot d\vec{S}, \quad (1)$$

where index m means determination of origin: *Maxwellian value*. Figures 2, 5, 6 and 7 show the way of brush elim-

ination. Conductivity path enters perpendicularly onto the isomagnetic circles of the magnetic field of two opposed axially magnetized synchronously rotating rings. The output of conductivity path is provided by the central conductor passing through the hollow shaft as shown in Figure 7. Assuming that we provide shielding of a wire \vec{j} of measuring circuit inlet, PHG function in Figure 2 will theoretically be similar to the brush solution of FHG [5, 1]. The difference is that in FHG, the outer wire moves towards outside homogeneous circles \vec{B}_1 , while in PHG, the inner wire \vec{i} moves against internal circles \vec{B}_2 . The outer wire \vec{j} is shielded in relation to the theoretical effects of relative movement of outer circles of magnetic induction \vec{B}_2 . In order to ensure good functionality of such shielding, we chose the superconductor based on YBaCuO crystals [6]. Shielding has two aspects:

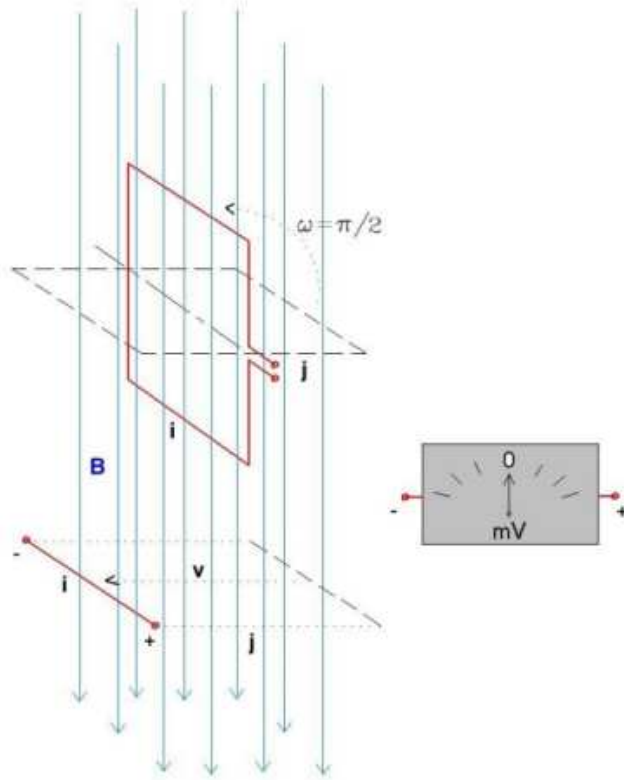


Figure 1. The Upper part of the image graphically illustrates the special case of a rectangular loop rotation of angle $\pi/2$, which causes a change of homogenous magnetic flux $\Phi = \vec{S} \cdot \vec{B}$ from maximum to minimum, and which is equivalent to the movement of the conductor of length \vec{l} along the path \vec{j} at the bottom of the image. In both cases, the same mean EMF \mathcal{E}_m should be induced.

- Provides a comparison of activity between PHG and FHG from the point of the Lorentz force creation - the shielded part of the wire will not interact with the external moving field alike the inner part of the disk FHG.
- Ensures theoretical induction unbalance between positive and negative contributions of EMF on the loop of

¹FHG inner portion does not move towards the magnet, because both of them are firmly connected.

length $l = 2i + 2j$, according to the integral of length from equation (1). This will allow assessing the induction occurrence in PHG from viewpoint of equations derived from the continuity equation.

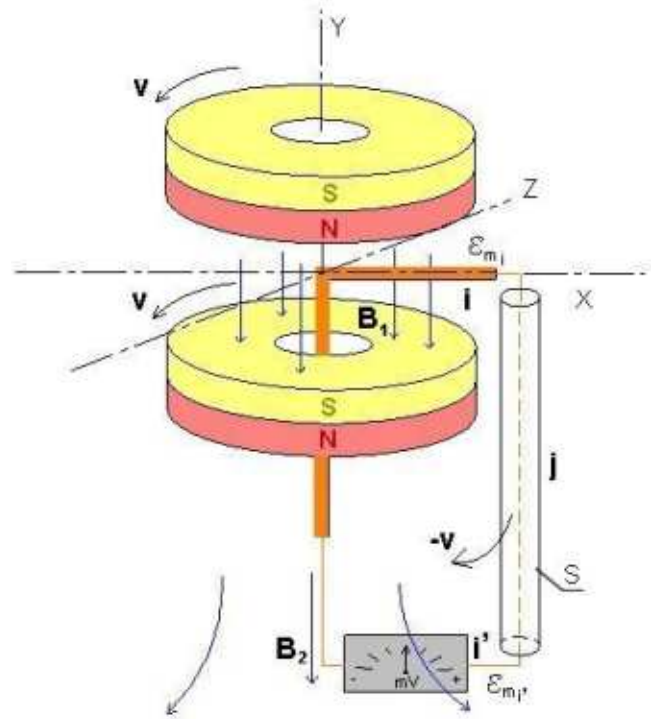


Figure 2. The axonometric scheme of layout of neodymium magnets and a wire shows the operating principle of the brushless homopolar generator (PHG). There on the inlet \vec{j} is indicated shielding by means of a superconductor S, which must close down the access of the outer field.

The brushless model of Faraday's generator should theoretically work in the same way as the brush solutions. The current theory is based on the fact that the cause of induction can be explained geometrically, generally by means of Stokes' theorem. It converts the linear integral of the electric intensity \vec{E}_m according to the length of the conductive winding to the surface integral of rotation $rot \vec{E}_m$ as per the area, which is closed by the winding in accordance with (1). The emergence of electric intensity \vec{E}_m should therefore be conditioned by direction and velocity \vec{v} of elementary lengths of winding in a homogeneous magnetic field of magnetic induction \vec{B} , or equivalently by changing of magnetic flux $\Phi = \vec{S} \cdot \vec{B}$ through the surface \vec{S} encircled during time Δt . Ultimately, this situation can be simplified and represented as shown in Figure 1, where in the upper part, the loop performs axial rotation by a quarter of the period. This partial turn of one winding creates a relative change in area $\vec{S} = \vec{i} \cdot \vec{j} \rightarrow 0$ against the magnetic induction \vec{B} during time Δt , which is encircled by the winding, and which the imaginary magnetic flux Φ of homogenous magnetic field passes. A mean $\mathcal{E}_m = \Phi / \Delta t = \vec{i} \cdot \vec{j} \cdot \vec{B} / \Delta t = \vec{i} \cdot \vec{v} \cdot \vec{B}$ should thus be induced.

According to this theorem, it is therefore equivalent to moving of the wire with length \vec{l} along the path \vec{j} with the speed $\vec{v} = \vec{j}/\Delta t$ as shown in the lower part of the Figure 1. So, even in the latter case, EMF $\mathcal{E}_m = \vec{E}_m \cdot \vec{l} = \vec{v} \cdot \vec{B} \cdot \vec{l}$ should be induced with the same mean value as in previous case. According to the Figure 2, it is obvious that the conductor i at PHG performs similar relative movement as in the bottom of Figure 1 with the fact that this movement is circularly oriented.

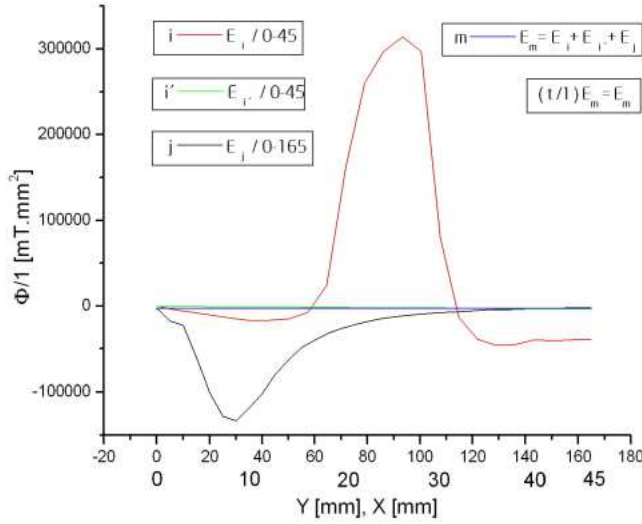


Figure 3. Chart of inductive flows per one turn that occur in closed PHG loop without shielding. The blue line represents the resulting sum of the EMF \mathcal{E}_m at one revolution per second. The red line represents the course of contributions \mathcal{E}_{m_i} on the path \vec{i} between the magnets. The black line represents the course of contributions \mathcal{E}_{m_j} of the part of the loop \vec{j} that is undesired and we need to shield it. Finally, the green line represents the residual course of contributions $\mathcal{E}_{m_{i'}}$ of the part of the loop $\vec{i'}$. The graph was created by the sum of measured values in accordance with the length integral in equation (1)

We will now analyze the application of current theory on the PHG: If we consider the plane $[x, y]$ parallel to the measuring loop, we get $\Phi = 0$ for the area $\vec{S} = \vec{i} \cdot \vec{j} = \vec{i'} \cdot \vec{j}$ that is closed by this loop. In non-shielded PHG, the change of induction flux is zero, and no voltage is induced. Unlike FHG, it is a different situation, because the loop is moving as a whole towards both inner and outer induction lines of neodymium magnets. Based on the formatin of Lorentz force, that theoretically affect free electrons by a relative movement of arm $\vec{i}, \vec{i'}, \vec{j}$ of closed loop $l = 2i + 2j$ towards vectors of magnetic induction \vec{B} , a theoretical balance between positive and negative contributions of EMF is achieved in accordance with the assumption $\text{div} \vec{B} = 0$ and in accordance with experimentally created graph in Figure 3: $\mathcal{E}_m = \int_0^l \vec{E}_m \cdot d\vec{l} = 0$. Thus, there exists both theoretical and experimental equivalence between induction flux through the surface of the loop and expected induced voltage in the loop of the conductor that surrounds

the surface, according to (1). Figure 3 shows results of the measurement in small distances from PHG magnets.

For creation of graph 3, it was favourable to always choose the perpendicular component of magnetic induction \vec{B} towards the wire l . If we measure it using the 3D Teslameter, the value of this component can be technically best read directly from the display of the teslameter. This can be achieved so that one of the coordinates of the 3D teslameter sensor must be identified with the wire axis, the other must be identified with the velocity vector and the third is the one that we use for the chart creating in the Figure 3 and 4, respectively.

In order to make sure that the movement of the wires in a homogeneous magnetic field, as shown in Figure 2, is a sufficient condition for emergence of the induction, a portion of the conductor should be shielded thoroughly. Thus, the induction imbalance between positive and negative contributions of EMF in the closed loop will be ensured.

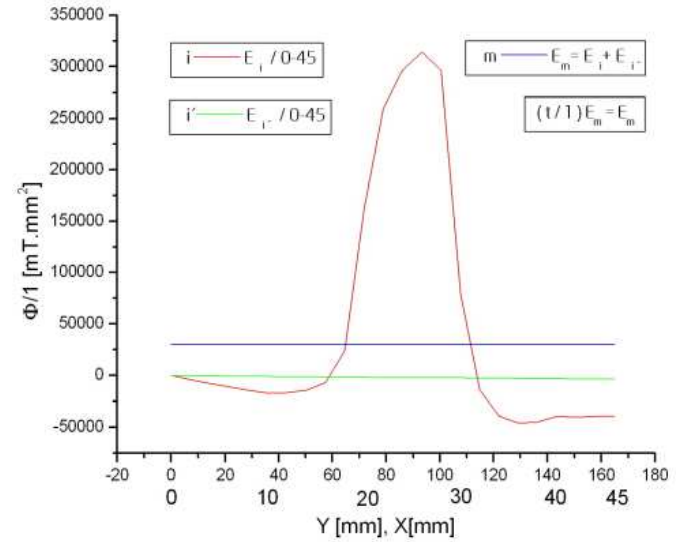


Figure 4. Similar to the previous graph of inductive flows per one revolution, which occur in closed PHG loop at the shielding of undesired return wire \vec{j} . The blue color represents the resulting sum of the EMF \mathcal{E}_m at one revolution per second, which can be assumed for a PHG adjusted in such a way.

Here we pursue the topic of the continuity conservation, which is the basis for mathematical theorems used in electrodynamics. The main premise for the use of these theorems is the validity of the continuity equation [2] that observes output and input flow. We know, however, that the magnetic field virtually does not present any real flux. It is rather an oriented field that is vanishing by increasing of the distance from one pole, and from the second pole, it acts the same. If we use the comparison to the flux and apply the direction, then it appears so that the flux from one pole is diluted in the space, and at the second pole, the flux becomes dense², thus, as if the field

²This comparison suits on gasses rather than on liquids, because with fluid we deal with velocity change rather than the change of density.

overflowed from the predetermined initial pole to the stated antipole without loss. Diluting and densification flow field should be done with a simple limitations in such way that $\text{div}\vec{B} = 0$ is in every measurable area [2]. If this restriction didn't exist, the flow of the field would at first have to fade out during receding in the space ($\text{div}\vec{B} < 0$) and, consequently at the antipole, the flow of the field would have to grow symmetrically by approaching ($\text{div}\vec{B} > 0$) to the original degree. In this case, even in the non-shielded PHG from Figure 2, a non-zero EMF would theoretically have to be induced, with respect to the asymmetric course of magnetic field in the measured area of the loop. The equivalence (1) would not hold. It is beyond the scope of this article to present here a table of experimental values, especially when there is an evident noteworthy correspondence with the assumption $\text{div}\vec{B} = 0$. A slight excess of \mathcal{E}_m on the outer loop of the graph of Figure 3 in this case is rather caused by the influence of measuring error.

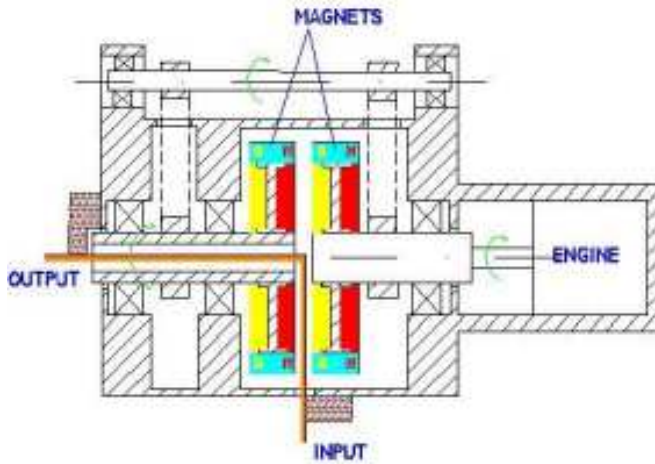


Figure 5. Schematic cross-section through technical solution of PHG, which allows to put in practice the principal arrangement of two opposite and axially magnetized neodymium rings and the wire entering between these rotating ring and going out, as shown in Figure 2.

Finally, we must observe that the physical application of the continuity equation for the magnetic field, in fact, theoretically describes a shape of field lines as an analogy to fluid flowing. The very ability of direct induction generated by simply moving the wires in an idealized homogeneous field does not logically results from it, anyway. It only mathematically well-corresponds with the equivalency of the surface integral. For example, analogy of Biot-Savart law that describes movement of electric charge in homogeneous magnetic field is used also for electrically neutral conductor – which is not exactly straightforward logical path. The only class of experiments, where is an objectively noticeable effect of the wire movement in the constant magnetic field, is based on FHG and even better on PHG, where there are no

³The circumference is not closed from perspective of the outer field of neodymium magnets.

brushes. It is the only class of experiments that can objectively verify the validity of Maxwell's equations. The reason is plain: We know how to simulate only a homogeneous radials of magnetic field. All other experiments are based on non-homogeneous fields and their theoretical conformity with the practically measurable electrodynamics is achieved using various electromagnetic constants in the form of e.g. permeability of the environment. It could thus lead to a false physical conception about the induction emergence.

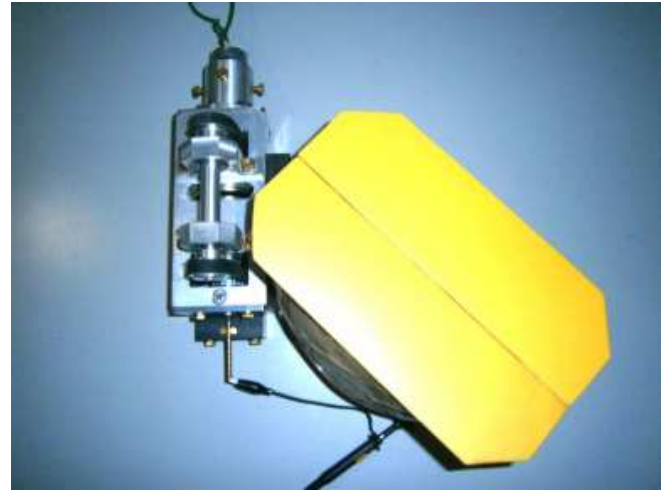


Figure 6. Brushless homopolar generator docked to the system of superconducting shielding - realistic experimental model.



Figure 7. Detail of the conductive path with output through the hollow shaft.

In order to be sure with Maxwell's equations (1), it is necessary to test the induction by a conductor movement at least in homogeneous circles of magnetic field. So let us focus on the emergence of the Lorentz force at the theoretically purer and technically more interesting PHG. The cross/sectional magnetic flux stays in this case unusable at PHG, because by outer shielding of wires using massive superconducting shielding up to 100 [mT] based on YBaCuO crystals [6], we actually get incomplete circuit³. Similarly, the loop is from this viewpoint incomplete also at FHG, where, vice versa, the inner part of the conductive path represents a relatively similarly shielded section so that due to technical solution, this part can not participate in the creation of EMF. Shielding is

oversized, because the measured induction values \vec{B} of the external magnetic field were reaching average of 23.76 [mT]. The measured maximum was 96.6 [mT]. Thus, it must happen due to the influence of the superconducting shield that the magnetic field deflects at the point of the shielding and bypasses conductor without affecting it. For the considered length of the circumference (thread) $l = 2i + 2j$ according to Figure 2, in accordance with graph in Figure 4, a theoretical induction balance between positive and negative contributions of EMF has to be violated, thus $\mathcal{E}_m = \int_0^l \vec{E}_m \cdot d\vec{l} \neq 0$.

Also, a measurable surplus induced voltage has to emerge, since a part of the circumference of length j does not take part in creation of the induction. The equivalence with the induction flux according to (1) can not occur because the shielding creates an open loop for the magnetic field. From the viewpoint of formation of the Lorentz force, there must be induced a differential voltage on shielded PHG equivalently to FHG. The blue line in Figure 4 shows a potential level that theoretically have to be obtained from experimental data after shielding the returning conductors \vec{j} . The final decision whether it is possible to doubt the physical validity of Maxwell's equations (1) must be done by this experiment.

However, tests for measuring PHG with shielded wire did not prove any induced voltage at the level of millivolts. We have repeatedly used a shielding technology as follows: At first, there was performed hypothermia of low temperature superconducting shielding of the measuring wire by means of liquid nitrogen at a distance of about 4 [m] from permanent magnets of PHG. Subsequently, PHG was slowly drawn closer and conductively docked into shielded wire with attached millivolt oscilloscope HMO722 or HMO2008 through the oscilloscope probe HZ154 or HZ200. When connected, the oscilloscope recorded closing of the circuit that has been verified by ohmmeter. After starting PHG up, there on the model it began the synchronous rotation of the two opposing magnets against the relatively rigid unshielded wire. Synchronous movement of both axial magnets is achieved by connecting of toothed pulleys according to the Figures 5, 6. In order to make sure how the induction is preserved in the reference system that is moving in relation to the frame, we have repeatedly conducted moving closer of the non-homogenous magnetic field of the neodymium magnet in relation to the measuring conductor \vec{j} on different places: Induction did not occur at points with shielding but did occur at places without shielding. This demonstrates the ability and relevance of usage of shielding.

Experiments that we made in this context have led us to the explicit finding: It is impossible to reach the phenomenon

of the homopolar induction without using such output and input conductors, specifically, that do not pass through the permanent magnetic field gradient⁴ in the perpendicular direction to a nonzero vector component \vec{B} of magnetic induction. In other words, which do not intersect the *transverse slope (crosswise gradient) of magnetic induction*. We have found out that the simulation of the continuous passing through a transverse slope of the magnetic induction must be ensured by brushes. The brushes probably represent an equivalent simulation which can be achieved, for instance, by winding up or unwinding a wire on the peripheral surface of the rotor of the Faraday disk - during winding up or unwinding, DC current will be induced in this wire.⁵ Experimental device simulating this fact is shown in the Fig. 9. We believe that the experiment, which at some point is disproving more than 150 years old theory, is a sufficient reason to rethink the understanding of the induction. (In our opinion, the Maxwell theory is regarded as the pride of coupling of mathematics and physical reality. Since 1865, this theory has one of the biggest influences on several generations of physicists). Regardless the explanation itself, it must be more complicated than Maxwell has declared by using simple mathematical logic.

We will give an example how the situation might appear in a brush FHG: Connection of the load, which connects the circuit to the FHG centre, creates the conductivity path with the potential differing from the conductive vicinity. During the rotation of the disc, this path with the shortest potential track, due to the relatively opposite movement of the brush and the surface of the rotor, begins to rip off and tilt to angle $\pi/2 - \varepsilon$ in contact surfaces. It is schematically shown in the blue curve in Fig. 8. In this way, a similar floating relative movement of the conductor is simulated, like during winding up or unwinding the springy cord. Continuous passing across the magnetic induction change is thus primarily ensured⁶. A response follows in accordance with the Lenz law⁷[7]: an increase of electric intensity causes current and potential channel. Free electrons from the surrounding areas are subsequently collected in this potential channel. These electrons accumulate into a wave that is synchronous with the relative motion of the brushes. In this incurred electron wave, there is a stable surplus of electric charge allowing additional amplification of the current via secondarily formed Lorentz force. [8, 1] We therefore assume that there are two effects simultaneously, where the second is dependent on the first one. We believe that this explanation is close to the physical reality, even though it

⁴The word "gradient" is used loosely in this report. It is not in a sense of mathematical definition.

⁵If the conductor is under electric current, automatic winding up of flexible wire takes place inversely, as well.

⁶The magnetic disc shows field declivity in the perpendicular direction to the axis - in radial direction - between the adjacent isomagnetic circles. This ensures that during brushes movement, the average conductive path relatively leans of the angle $\pi/2 - \varepsilon$ and the simulation of the conductor passing crosswise the field declivity occurs.

⁷The law does not originally specify what kind of change it is - the magnetic flux change is attributed to it later in modern times.

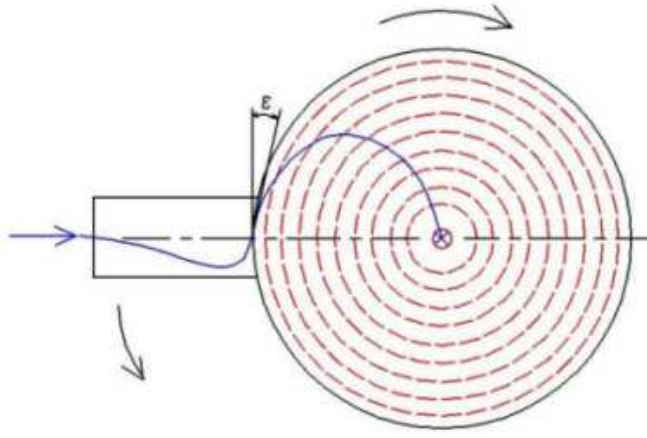


Figure 8. The notion of middle track of the conductivity path in the rotating FHG.



Figure 9. The experimental model with the flexible conductor, which is winding up on the axially magnetized magnetic disc.

does not seem elegant at the first glance. In other words, the movement of electrically neutral wires in a hypothetical homogeneous field does not generate Lorentz force and therefore no voltage is induced - thence just like it is not induced in experimental without brush devices. In this case, the Lorentz force arises only in an inhomogeneous field. We think that the experiment based on homogeneous circles as in Fig. 6 is more credible than experiments based on Helmholtz or improved Maxwell coils. These coil systems achieve good axial homogeneity, but circle homogeneity is worse. Even relatively negligible gradient can generate induced voltage. The same is surely valid for small areas of strong reference fields, for example neodymium magnets. All of these fields in certain locations may have a negligible value of the gradient with respect to the induction. But the gradient exists and therefore the measured induced voltage also exists under the influence of possible changes in cross-section of a loop placed in this field. This could again lead to illusive and false confirmation, that the flow change is necessary and sufficient

⁸Maxwell's mathematical determination of the intensity direction by adding the vectors \vec{B} and \vec{v} is also reflected in the unit vector \mathbf{e}_E . Experiments have led us to a completely new methodology of physical determination of the intensity direction. It is more complicated and it is possible to reliably determine it only from the transverse gradient. For simplicity, it is advantageous to preserve current mathematical convention.

condition of the inception of electric induction. Absolute prediction of the measured values of the induced voltage is a consequence of tabular constants, which have always been set in a standardized gradient. It is certainly not necessary to mention that predictions of these absolute values are not too reliable, yet regarded as a good result.

Transformation of the Faraday's law from idealisms to realisms

The magnetic induction change is only a necessary condition, but not a sufficient one. Similarly, the transverse slope of the magnetic induction is also a necessary and insufficient condition. Both of these conditions together ensure necessary and sufficient condition: a temporal change of the transverse gradient of the magnetic induction.

In differential form, Maxwell's interpretation of Faraday's experiments is defined (Faraday's Law):

$$\text{rot} \vec{E}_m = - \frac{\partial \vec{B}}{\partial t} \quad (2)$$

In the context of the experiment above, we try to establish a relation which includes both of these necessary conditions and which could express physical nature of the induction. We believe that the best candidate is the following formula:

$$\vec{E} = \left| - \frac{\partial \vec{B}_\perp}{\partial t} \right| \mathbf{e}_E, \quad (3)$$

where \mathbf{e}_E ⁸ is the unit vector which takes over the role of polarity and determines the direction of the intensity \vec{E} . The partial derivative $\partial \vec{B}_\perp / \partial t$ represents the time change of the magnetic induction during movement of the perpendicular component of the wire velocity \vec{v} to the vector \vec{B} . Perpendicularity sign \perp means that the crosswise induction declivity exists in the direction of this perpendicular component of the conductor movement. It means that in the field with a certain density of hypothetical induction lines, two adjacent lines have different values of induction and that the path of the moving conductor crosses these induction lines.

The electric intensity vector \vec{E} is generated perpendicularly to the plane formed by the two vectors \vec{B} and \vec{v} . According to this formula, the initiation of the electric intensity is caused by:

- existence of the cross declivity $\partial \vec{B}_\perp / \partial \vec{x}$ in the direction \vec{x} perpendicular to \vec{B} of the moving conductor;
- time change of this cross declivity towards the wire.

Assuming that the actual physical reason for the generation of the electric intensity \vec{E} is described by equation (3), we have to find a mathematical relation to the present hypothesis, i.e. to $\vec{E}_m = \vec{B} \times \vec{v}$. [3, 4] In the relation (3), which

count with time change of the cross declination, we can, in the spirit of existing conventions, substitute the orthonormal base $\mathbf{e}_E = \mathbf{e}_B \times \mathbf{e}_v$. So, we can define a mathematical equivalence $\partial \vec{B}_\perp / \partial t \Leftrightarrow \partial \vec{B} / \partial t$, because from one side, the general formula $\partial \vec{B} / \partial t$ includes values of the time change of the cross declination $\partial \vec{B}_\perp / \partial t$ and on the other hand, at violation of orthogonality, for determination of its value there is relevant mutual relationship of the direction and magnitude between \vec{B} and \vec{v} :

$$\vec{E} = \left| -\frac{\partial \vec{B}}{\partial t} \right| \frac{\vec{B}}{||\vec{B}||} \times \frac{\vec{v}}{||\vec{v}||} = \left| -\frac{\partial \vec{B}}{\partial t} \right| \frac{\vec{E}_m}{||\vec{B}|| ||\vec{v}||}. \quad (4)$$

In the case of integration, (2) according to the area we come to relation (1) and in the case of integration (4) according to the wire length we come to formally similar equation for electromotive voltage:

$$\mathcal{E} = \oint_l \vec{E} \cdot d\vec{l} \quad (5)$$

Vector \vec{E} is oriented just as \vec{E}_m , but with different values. Besides the angle between both vectors \vec{B} and \vec{v} , the values of the vector \vec{E} are influenced by $\partial \vec{B} / \partial t$.

We can show the relation between \vec{E} and \vec{E}_m in differential form if we define immediate unit declination of the magnetic induction in the direction of path \vec{x}_i (Cartesian coordinates) of the conductor movement

$$\gamma(i) = |(\partial \vec{B} / \partial \vec{x}_i)| / (||\vec{B}||), \quad (6)$$

where \vec{B} is the function of the vector argument of the spatial radius \vec{r}_i (spherical coordinates). This radius is oriented towards the beginning of the path \vec{x}_i of the conductor movement in the magnetic field with induction $\vec{B}(\vec{r}_i)$. [9]

For the immediate induction we obtain a relation that expresses the relationship between the Maxwell's conception of electric intensity $\vec{E}_m = \vec{B} \times \vec{v}$ and the interpretation in context of the experiment described here.

$$\begin{aligned} \vec{E} = \gamma(i)(\vec{B} \times \vec{v}) &= \left| \frac{\partial \vec{B}}{\partial \vec{x}_i} \right| \frac{\vec{B}}{||\vec{B}||} \times \vec{v} = \\ \left| \frac{\partial \vec{B}}{\partial \vec{x}_i} \right| ||\vec{v}|| \frac{\vec{B}}{||\vec{B}||} \times \frac{\vec{v}}{||\vec{v}||} &= \left| \frac{\partial \vec{B}}{\partial t} \right| \frac{\vec{E}_m}{||\vec{B}|| ||\vec{v}||}. \end{aligned} \quad (7)$$

We have achieved the final compliance (4) due to the application of the vector product definition and that \vec{x}_i has the same direction as \vec{v} . It should be pointed out that the general equations (4) and (7) represent a generalizing mathematical convention, physically relevant are just interactions according to (3), hence only the movement of the wire through the crosswise declivity of the magnetic induction is relevant. It is beyond the scope of this article to solve the physical aspect of the influence of the declivity orientation. Therefore, for brevity, we always use an absolute value of the declivity and

the orientation of the intensity is mathematically determined by the vector products $\vec{B} \times \vec{v}$.

Furthermore, for the sake of simplicity, we set the coefficient $\gamma_\phi = (\int_S \gamma(i) \cdot d\vec{S}) / \vec{S}$ throughout the integration area \vec{S} as an average unitary declivity of the field in the direction of the moving conductor. Then we can write

$$\gamma_\phi \int_S \text{rot} \vec{E}_m(\vec{x}_i) \cdot d\vec{S} = \oint_l \vec{E}(\vec{x}_i) \cdot d\vec{l}. \quad (8)$$

When we integrate both sides (8), the left hand side according to the area closed with conductor and the right hand side according to the conductor length, we get scalar result:

$$\gamma_\phi \mathcal{E}_m = \mathcal{E}. \quad (9)$$

For the technical practice that has created a set of constants and coefficients on the basis of the Maxwell equations, this result does not mean any change, as the crosswise declivity occurs in the methodology of their specification. The result may be relevant only for the non-standard industrial applications. This illustrates that if there does not exist any average value of the gradient according to (3), (4) and (7), then it means that there must be $\gamma_\phi = 0$ and, in compliance with the phenomenon of the without brush homopolar generator, no homopolar induction occurs.

For values γ_ϕ in the interval $0 < \gamma_\phi < 1$ a new relationship gives necessary correction with physical practice. For the values $\gamma_\phi = 1$, it will be given the same value for both relations (1) and (5). It should be noted that each value of the average unit declivity (and thus also the value of 1) binds itself a large class of values of absolute declivities, from very low up to extremely high values - it follows from the unit declivity (6) definition. It would be surely interesting to examine which of the average unit declivities occur mostly in practice. If we define $\gamma_\phi > 1$ it means that the gradient is high, for example for neodymium.

At this point, it could arise a false impression that weak fields can have high gradient and thus could cause induction with high acceleration, which would be in contradiction to the practice. A good example, that the declivity of the field is dependent on the magnitude of the magnetic induction (or magnetic flux density), is the magnetic field around a long wire $B = \mu I / 2\pi r$. The value of the current determines the magnitude of the magnetic induction and thence the flatness and steepness of the declivity, as shown by the derivative by r , which is $(\mu I / 2\pi) / r^2$. The declivity at a given distance r is proportional to I , and hence to the magnetic induction B . Thus, it cannot happen that weak fields achieve higher inductive effects than strong fields. However, strong fields with a locally weak gradient may reach only small inductions in this location.

Discussion

The Maxwell's mathematical insight with emphasis on the time change of the magnetic induction flux predicts functionality of the homopolar brush generator, which is thus mistakenly taken as the evidence that the change in the flux of magnetic induction is sufficient physical quantity for realization of electric induction. For this reason, it mistakenly predicts that a similar realization without brush design should be functional as well.

However, in the context of the findings above, the temporal change of the inductive flux does not lose its physical meaning - that consists primarily in showing the speed, in which the conductor is passing through gradient of the field.

In accordance with the above experiment, equations (8), (9) predict that by the movement of electrically neutral wires in a homogeneous magnetic field happens nothing at all - no Lorentz force will be generated and therefore no voltage will be induced. In this text, equation (3) adopts the status of a physical law. The relation (2) herein considered is physically non-essential (from standpoints of induction) and creates hypothetical and unverifiable idea of swirly magnetic field. It describes time changes only of geometric quantities in 3D space. Equations (7) and (8) indicate a necessary theoretical correction of the contemporary equations in order to predict the described experiment correctly.

Values of the transverse declivity of the reference fields were covertly embedded into tabular quantities. Tables can thus be used in further decades with Maxwell platform as well, without loss of accuracy, at least if that will deal with ordinary project calculations.

If we let according to the result (9) $\Delta t = konst > 0$ and fix the non-zero increases of both surface $\Delta \vec{S}$ and length $\Delta \vec{l}$ of the conductor, we get two linear relations, see Figure 10. The graph shows the difference between the values of EMF for the concept with relation $E(\Delta \vec{B}_{\perp}) = \Delta \mathcal{E}$ derived from (3) and (5) and current conception with relation $E_m(\Delta \Phi(\Delta \vec{B}_{\perp})) = \Delta \mathcal{E}_m$ derived from (2) and (1). The change of transverse slope causes a change of magnetic flux, however, the change of magnetic flux does not theoretically have to cause the change of transverse slope.

There are five advantages of the presented concept:

- implies the prediction of the PHG behaviour and thus respects the results of wider range of experiments,
- is fixed on the integrating constant $C = 0$,
- unquestionably eliminates Faraday's paradox [1],
- can give equivalent results consistent with the previous practice, because the average declination γ_{ϕ} is related to the non-closed area \vec{S} likewise the magnetic flux,

- reveals a wide range of up to now hidden possibilities of new technical realizations.

The diagram shows that the Maxwell electromotive voltage \mathcal{E}_m assumes non-zero values also for zero slopes. It is obvious that if we consider the presented proposal assuming $E(\Delta \vec{B}_{\perp})$ to be the most appropriate with the physical reality, and at the same time we defend the Maxwell's concept as a best proven practice, using the methodology of electrodynamic constants, it must lead to more realistic current Maxwell concept $E_m(\Delta \Phi(\Delta \vec{B}_{\perp}))$ in the whole scale of declivity values. Similarly, it is shown by the green curve (in some parts asymptotic) that it is consistent with the result (9).

The existence of Stokes Theroem encourages an illusion, that the electromagnetic induction is caused by a change of electromagnetic flux in time. Stokes theorem includes time changes of the magnetic induction \vec{B} in a form of rotation vector $rot \vec{E}_m$. False notion of the physical correctness of this concept is therefore perfect. The physical incorrectness is detectable only in the proximity of the limiting zero-point of the transversal declivity, thus, only by a real simulation of a movement in a homogeneous magnetic field.

This article describes a brushless homopolar generator. The same formula applies to the inverse phenomenon in the Pure homopolar motor PHM⁹. To demonstrate the collision of contemporary theoretical electrodynamics with practice, it is possible to use presented generator as a motor.

Demonstrations, when the theory is not consistent with practice, are as follows: e.g. The grant of patent in Czech Republic PV 2011-293 (DC electromotor) or the patent US5977684(A) in USA, which at first glance appear to be functional only in theory. Upon closer examination, they cannot be functional even from the perspective of Maxwell's electrodynamics and in this case they would be contrary to the law of continuity, not to say the energy. That is clear as soon as the DC coils would replace the permanent magnet. Very basic search pointed at least on the next six patents. The experiment described in this article could theoretically get all of these solutions into operation. The reality, however, proved different. Assertions in the preceding sentences can be proven by demonstration of purchased dysfunctional model, which is for the purpose of commissioning equipped with electronics and violates an advantage declared in PV 2011-293. After removing the electronics, the device dysfunctionality is evident. As the significant support for finding discrepancy between theory and practice we consider the fact that despite the advantages of similar solutions, none appears in practice. For example, there is no wind power plant, which would favourably take advantage of similar solutions and produce directly the brushless direct current. Classic high performance commutating (brushed) DC generators are commonly used. Brushless AC generators with electronic rectification

⁹Meant as Pure Homopolar Motor: i.e. motor that does not need any brushes, electronics or semiconductor to ensure the directly of connection a direct current.

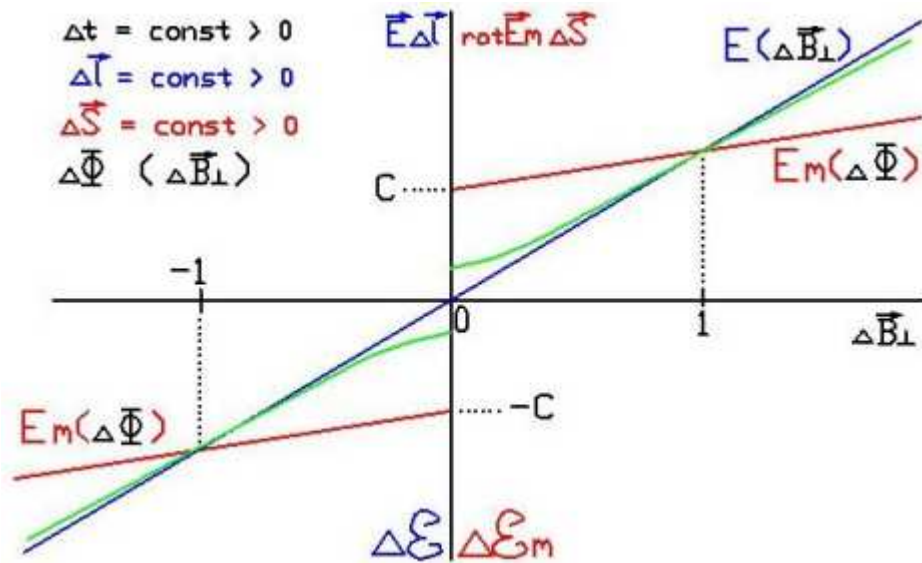


Figure 10. A graphical study of comparison of the course of Maxwell's prescription E_m and herein proposed concept of E with common vector variable of crosswise declivity ΔB_{\perp} at constant and non-zero increments of $\Delta t, \Delta I, \Delta S$

for subsequent further processing into the distribution network come to the forefront during last years.

The goal of this report is to point out a deeply rooted myth of contemporary theoretical electrodynamics, that there can exist a technical solution that would use a homopolar induction (or inverse action) without brushes, without electronic and without semiconductors. And the induction (or inverse action) should take place in a homogenized electromagnetic field (for example in homogenous circles).

This article aims to point out that there cannot exist functional solutions of generators or motors within the meaning of definitions of PHG/PHM Acquisition of the patents for these solutions pose for authors award, honour, social and career motivation. If a real model is not constructed, the author may never get to know about the error. Even a company that purchases such a patent and is actually misdirected, does not have any meaningful interest to publish the situation. Conversely, such a company is motivated to get a non-functioning solutions into operation by using of a proven extension. The company can be presented by the patent at most in terms of marketing. Feedback from industry to academic sub-consciousness is basically blocked by this.

Methods

It is clear from this article, that we have used the oldest physical methods, i. e. model construction methods that demonstrate the function. We used our own idea how to identically simulate theoretical assumptions of FHG function onto PHG. Finally, we used a modern method of shielding by means of high-temperature superconductors with efficiency higher than 100 [mT] specified by the manufacturer. To maintain the appropriate temperature, standard cryogenic technology based on liquid nitrogen was used. The measurement itself

did not require any special facility or method. We were investigating the processes in the demonstrative apparatus at the millivolt level. Further increase of accuracy does not make any sense due to significant noise at that low voltage values. The result of this experiment is noticeable. In the analysis, we have used the description variant that preserves the vector nature. It is easy to see that this analysis continues in so called Faraday law. Furthermore, in the boundary point it explains the cause of its failure and corresponds with reality.

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Author contributions statement

P.I. designed the study, performed the experiment, analysis and wrote the paper. I.V. performed a complete translation from the perspective of an electrical engineer. M.I. performed a final proof reading work and an English translation from the perspective of mathematics. All authors reviewed the manuscript.

Additional information

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